

DECLARATION OF THOMAS A. DAVIS, Ph.D. UNDER 37 C.F.R §1.132

I, Thomas A. Davis, declare as follows:

I am a U.S. citizen, and I presently reside at 5 Sweet Gum Court, Columbia, SC 29223. I am the sole inventor of the subject matter of U.S. Patent Application Serial No. 10/632,369, titled: *Production of purified water and high value chemicals from salt water*, which was filed on August 1, 2003, the patentability of which is presently at issue.

I am presently employed by the University of South Carolina, and my position is Research Professor. Prior to assuming my present position, I worked as an independent consultant in the field of membrane processing and industrial separations. I have also served as Director of Research and Development for The Graver Company in the area of water treatment processes. I was also employed as a Senior Staff Engineer at Exxon Research and Engineering Company, and worked in the field of membrane separations. I have served as Biomedical Engineering Section Head at Southern Research Institute, where I supervised development work with medical devices, water treatment and pollution control. I have also been employed as an engineer with Deering Milliken Research Corporation, Spartanburg, SC.

I have published over 25 books and journal articles and am an inventor of 12 issued U.S. patents. I have been active in the field of water treatment and membrane separation processes, with which the present patent application deals, for the past 40 years.

The information provided below describes my opinions regarding various aspects of the grounds for rejection of claims that were asserted by the Patent Office in its Office Action of September 12, 2005, including the interpretation of certain parts of the references that were cited in support of those rejections. In preparation for providing this opinion, I have reviewed the Office Action dated September 12, 2005, the specification and claims of the present patent application, and the references that were cited by the Patent Office in support of the grounds of rejection that were asserted.

In summary, it is my opinion that none of the three patents cited as prior art in the recent Action describe my invention as I have described it in the claims of the present application, and it is also my opinion that no combination of the teachings of any two or

all three of the cited patents would have made my invention obvious to a person of ordinary skill in the art of desalination and water treatment, for the reasons that follow.

In the present Office Action, U.S. Patent Nos. 6,030,535 to Hayashi *et al.*, 4,036,749 to Anderson, and 5,458,781 to Lin were cited as teaching certain aspects of my claimed invention. I will explain how the devices and methods taught by these references differ from the invention that I have made.

U.S. Patent No. 6,030,535 to Hayashi *et al.*:

The overarching differences between the Hayashi '535 patent and my invention can be understood if one examines the objectives and the means of attaining those objectives. Both inventions have an objective of producing potable water and salt from seawater without expending the total heat energy that would normally be required to evaporate all of the water in seawater. Hayashi's objective is to produce a salt with a composition that closely approaches the mineral composition of sea salt. But my objective is to produce pure NaCl that is not contaminated with the other components of seawater.

Both Hayashi and I use reverse osmosis (RO) and electrodialysis (ED) to reduce the heat energy requirements, and both approaches address the problem of potential precipitation of CaSO_4 in the concentrate streams of the process if the concentrations of Ca^{++} and SO_4^- ions reach excessive levels. Hayashi's approach is to reduce the concentration of Ca^{++} ions in an elaborate pretreatment process and to reject SO_4^- ions with uni-valent-anion-selective membranes in the ED. My approach is to reject SO_4^- ions with uni-valent-anion-selective membranes in the ED and to reject Ca^{++} and Mg^{++} ions with uni-valent-cation-selective membranes in the ED, because it is desirable to minimize the concentrations of all divalent ions in the produced salt.

Hayashi in '535, Col 3, Lines 33-41 teaches the use of "an ion exchange membrane having selective permeability for preventing the permeation of predetermined divalent anion" (that would be sulfate or carbonate) for the purpose of scale prevention. Indeed scale prevention can be achieved by the use of univalent-anion-selective ion-exchange membranes in the electrodialysis. He also states that "it is preferable that the salt obtained by evaporation of the concentrated salt water contains minerals in the salt water." Hayashi's desire to have divalent cations in the salt

product is reiterated in Col 6, Lines 55-58. These statements emphasize that he wants to keep the calcium and magnesium in the concentrated solution produced by the electrodialysis, and that would be done by not using univalent-cation-selective ion-exchange membranes in the electrodialysis. In my process it is preferable to exclude calcium and magnesium ions as well as sulfate and carbonate ions from the concentrated salt stream in order to produce a NaCl product suitable for industrial use, and we accomplish that by using both types of membranes, univalent-anion-selective and univalent-cation-selective, for the purpose of avoiding the presence of divalent ions in the concentrated salt and for the purpose of isolating and concentrating the magnesium in the diluate stream of the electrodialysis.

As to the assertion in the Action that Hayashi teaches operation of the ED unit at a high pressure, it must be noted that Figures 1 and 2 of the '535 patent show no pumps and no valves, so there is no way to tell from those drawings where Hayashi intended to apply pressure and relieve pressure in the integrated process that includes RO and ED. Figure 3 of the Hayashi '535 patent shows a pump to push the water through the pretreatment equipment, but one skilled in the art would understand that the pump shown in Figure 3 would not apply the 56 kg/cm² of pressure that Hayashi says (Col 12, Line 19) would be needed to push water through the reverse osmosis membrane, because it would be very unexpected to operate the entire system at such a high pressure. The only mention of high-pressure pumps for the reverse osmosis is in the discussion of power consumption in the section from Col 17, Line 63 to Col 18, Line 17. There is nothing whatsoever in '535 to indicate that Hayashi anticipated operating the ED under a pressure higher than that required to circulate the solutions through the ED solution compartments.

Hayashi in '535, Col 12, Lines 15-21 provides some numbers about osmotic pressure of seawater that require clarification. The salinity of seawater is about 35,000 mg/L, and at that level of salinity the osmotic pressure is about 26.5 kg/cm². The value of 0.7 kg/cm² mentioned in Line 16 is for a solution concentration of 1000 mg/L.

U.S. Patent No. 4,036,749 to Anderson:

I also differ with the assertion in the Action that Anderson in U.S. Patent No. 4,036,749 (the '749 patent) teaches a process that includes both RO and ED in

combination. The '749 patent describes a pretreatment process to make water more suitable for desalination by a variety of desalination processes. In Col 6, Line 16, Anderson states that "the desalination process can also comprise electrodialysis" and then goes on to describe ED, but he does not teach that ED is used in combination with RO. In Col 5, Line 7-8, Anderson states that "the formation of brine in step 34 can be conducted by any of a plurality of processes." He does not say "a combination", he says "any". "Any" is singular; the plural is "some". Therefore, "any" cannot be construed as "a combination". The term "plurality" here refers to a list of desalination process from which he could select one. In Col 6, Line 55, he states "regardless of the desalination process conducted in step 34", which again implies that one process would be selected from the list of candidates. Finally in Claims 6-10 he mentions the desalination process one-at-a-time with no suggestion that the desalination processes would be combined.

The examiner's comments on Page 4 of the Action regarding Claim 3 are difficult for me to understand. I see nothing related to uni-valent-selective membranes in '749, Col 7, Lines 49-68 or in Col 8, Lines 1-7.

As to the examiner's comments about Claim 5 where there is recirculation back to the RO, it must be noted that my Claim 5 differs from '535 in that only solution that passes through ED compartments between the non-selective membranes is recirculated to the RO, whereas '535 teaches recirculation of solution that passes between a cation exchange membrane and a uni-valent-selective anion-exchange membrane.

The examiner's comment about Claim 6 is unclear to me. Claim 6 establishes a minimum limitation of 20% for the concentration of salt solution from the ED, and that value is higher than the concentration that would normally be expected. In '535 Col 12, Line 23 the expected concentration of salt solution produced by ED is 17.7%.

The examiner's comment about Claim 7 seems to be pertinent to Claim 8 not Claim 7.

Regarding Claim 5, there is a considerable difference between the concept of drying to produce salt as taught by Hayashi and the concept of evaporating water for the purpose of creating conditions conducive to the crystallization of pure NaCl.

Hayashi's purpose, as stated in Col 18, Line 42, is to produce "a special salt containing minerals in seawater." My purpose is to exclude other minerals from the NaCl product. Hayashi does not specifically address the issue of bromine or bromide ions, but the fact that his process does not produce a bittern stream would imply that the bromide ions would appear in his salt product. There is no suggestion in the '535 patent that bromine would be a byproduct, and there is no mechanism in the Hayashi process to produce a bittern from which bromine could be recovered. Indeed, the recovery of bromine goes against Hayashi's objective of producing "a special salt containing the minerals of seawater."

U.S. Patent No. 5,458,781 to Lin:

The examiner cites '781 by Lin that teaches the use of NF to produce NF permeate containing bromide ions and NF reject that contains divalent ions. In my application the rejection of divalent ions by NF is important but the permeation of bromide is inconsequential. In my process the NF treats ED diluate from which most of the bromide ions have already been removed, because the uni-valent-anion-selective membranes transport bromide ions in preference to chloride ions. Thus, my process could exploit the ability of NF to reject divalent ions even if the NF permeate were not enriched in bromide.

I declare that all statements herein made of my own knowledge are true and that all statements made herein on information and belief are believed to be true. I do hereby state that I am aware that willful false statements and the like are punishable by fine or imprisonment, or both (18 U.S.C. §1001) and may jeopardize the validity of the application or any patent issuing thereon.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on: December 22, 2005 (Date)

Signature: Thomas A Davis

Thomas A. Davis